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# THE MORE IMPORTANT INSECT AND FUNGOUS ENEMIES OF THE FRUIT AND FOLIAGE OF THE APPLE.

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# LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
*Washington, D. C., February 3, 1912.*

SIR: We have the honor to transmit herewith, and to recommend for publication as a Farmers' Bulletin, a manuscript entitled "The more Important Insect and Fungous Enemies of the Fruit and Foliage of the Apple," by A. L. Quaintance, of the Bureau of Entomology, and W. M. Scott, of the Bureau of Plant Industry.

During the past few years the summer spraying of apple orchards has undergone important improvements, and many questions of detail have thus been raised in the minds of growers. The present paper, based upon results of the department's investigations of the subject during the past several years, is intended to answer these questions and to furnish information which will enable the orchardist to obtain the maximum benefits for his outlay in time and money in spraying operations.

Respectfully,

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*Chief, Bureau of Plant Industry.*

HON. JAMES WILSON,
*Secretary of Agriculture.*

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# THE MORE IMPORTANT INSECT AND FUNGOUS ENEMIES OF THE FRUIT AND FOLIAGE OF THE APPLE.

## INTRODUCTION.

The spraying of apple orchards has received a great impetus during the past few years by reason of the increased demand for good fruit and the satisfactory prices received therefor. While most commercial orchardists have been spraying for a good many years, the practice has not been as general among small orchardists as is desirable, and the present profitableness of apple culture has been the principal factor in awakening an interest in a crop heretofore much neglected by them.

A few years ago it was felt that orchard spraying was on a rather definite basis, but recent improvements in spray materials and apparatus for their application have contributed to raise many questions of detail in the minds of fruit growers. These questions have to do with the best spray to use; times of making applications; grade of chemicals to purchase; the desirability of preparing sprays at home in preference to use of commercial preparations, etc.

It is the aim of the present paper to furnish the orchardist necessary information for summer spraying, or spraying trees in foliage, as opposed to treatments during the dormant period of trees, as for the San Jose scale, blister mite, etc. The principal insects and diseases affecting the fruit and foliage of the apple are first considered, and with the illustrations should be easy of recognition. This is followed by a consideration of the sprays recommended, and directions for their preparation and use. Owing to the extended area in the United States over which the apple is cultivated, it is necessary to refer to certain insects and diseases which are of interest in more or less restricted localities, and to indicate the appropriate treatment for the same in the sprays schedule. It is believed, however, that the orchardists in the New England States, as well as the orchardists in the Ozark regions of Arkansas and Missouri, will have no difficulty in determining the particular applications necessary under their respective conditions.

## THE CODLING MOTH.

The larva of the codling moth (*Carpocapsa pomonella* L.), sometimes called the apple worm, is well known alike to growers and consumers of apples. It is the principal cause of wormy apples, and its

control must be secured in profitable apple growing; otherwise from one-half to three-fourths or even a larger proportion of the crop will be wormy and unfit for market. No orchard insect, perhaps, is more successfully controlled than this one; and by careful spraying the fruit grower may expect to protect from its injuries from 90 to 95 per cent of the crop. Owing to the great extent of the apple-growing industry, there is, however, in the aggregate a large shrinkage in the quantity of marketable fruit, resulting from injuries by the codling moth. This shrinkage in the United States each year represents a loss of about $12,000,000, and some $3,000,000 or $4,000,000 are annually spent for sprays and labor in its control.

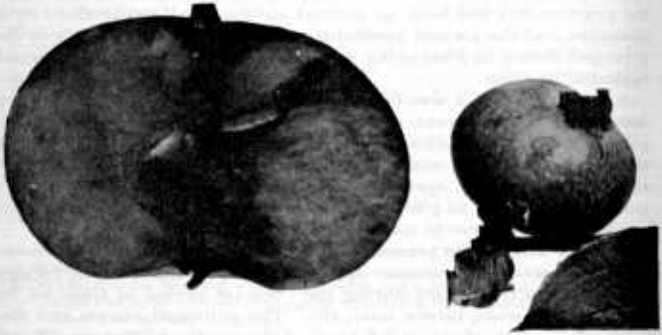

FIG. 1.—The codling moth larva (*Carpocapsa pomonella*) and its work: On the left, mature apple, showing full-grown larva and its work; on the right, frass from calyx end of young apple, infested with first-brood larvæ.

## CHARACTER OF INJURY.

Wormy apples are shown in figure 1. The presence in apples of the apple worm early in the season is usually indicated by the occurrence at the calyx end of more or less frass. Fruit injured early in the season and while it is small mostly falls to the ground. Larvæ of the second and later broods occur when the fruit is more nearly grown, and it is the injuries of these broods that are observed in fruit on the market. The severity of attacks varies somewhat from season to season, and especially in different parts of the country, depending upon the number of broods of larvæ produced in the region in question.

## NUMBER OF GENERATIONS.

The number of broods of larvæ of the codling moth for the country as a whole varies from practically one to three. Throughout the New England States and southward, at least to about the latitude of Washington, there is one full brood of larvæ each year and a partial second. In the northernmost part of the territory indicated, as in Maine and New York, the second brood of larvæ will be slight, varying in extent from season to season; while in the southern portion of this territory it is normally quite large, and during certain years there are practically two full broods. In the more southern States, as the Carolinas on the east and Arkansas on the west, there are probably three broods of larvæ each year. This has been determined to be true for Arkansas and Kansas. In New Mexico it is thought that the insect is three-brooded also.

It has been determined that there are two full broods of larvæ in States of the far West: Washington, Oregon, Idaho, Utah, and Colorado. The effect of such seasonal conditions as drought and temperature on the number of first-brood larvæ transforming for a given locality is quite marked. Thus, in Erie County, Pa., in 1907, with an abnormally late spring, only 3 per cent of the first-brood larvæ transformed, as compared with 68 per cent which transformed the following year and 23 per cent the next year.

## DESCRIPTION AND LIFE HISTORY.

**How the insect passes the winter.**—Upon leaving the fruit in late summer or fall larvæ seek protected places upon the trees, such as holes, cracks, crotches of limbs, or under bark scales, or even underneath trash on the ground, construct tough silken cocoons, and here pass the winter in the larval condition. Large numbers of larvæ are carried to storage houses in apples in the fall, where later they spin cocoons in the boxes, bins, or barrels, or in cracks in the floor or sides of the house. In the orchard large numbers of larvæ are destroyed during the winter by birds, principally woodpeckers, but in storage houses a large proportion doubtless survive, the moths from which fly to the orchards in the spring and constitute an important source of infestation.

With the coming of spring the larvæ enter the pupal stage, and about the period of blooming of the apple, or somewhat later, the moths begin to appear, continuing to emerge for three or four weeks, while belated moths may not emerge until considerably later.

**The moth.**—The adult, or miller (fig. 2, *a*), is rather variable in size, but the maximum wing expanse rarely exceeds three-fourths of an inch. The forewings above are of a brownish gray color, with numerous cross lines of gray. Near the tip of each wing is a con-

spicuous brown spot, or ocellus, in which are two irregular broken lines of a metallic coppery or golden color. The hind wings above are grayish brown, becoming darker toward the margin, which bears a delicate fringe, at the base of which is a narrow dark line. When at rest on the grayish bark of an apple tree, the moth in color so harmonizes with its surroundings that it is not readily distinguished, and the insect in this stage is perhaps little known to orchardists.

**The egg.**—The eggs are small, flat, somewhat oval in shape, and of about the size of a pinhead. When recently deposited they are of a

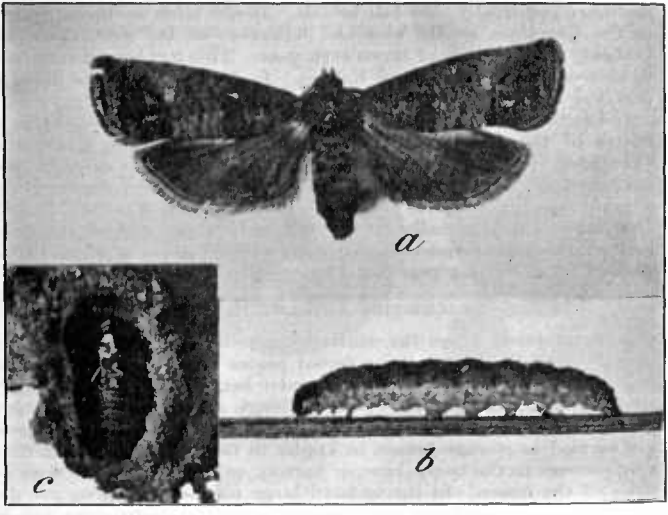


FIG. 2.—Stages of the codling moth: *a*, Moth; *b*, larva; *c*, pupa in its cocoon. Much enlarged.

pearl-white color, but become darker with the development of the embryo, which after a few days is easily distinguished as a reddish ring within the egg. Under a lens the surface is seen to be covered with a network of ridges, coarser toward the edge. The eggs of the first generation of moths are deposited mainly on the leaves and twigs, comparatively few being placed on the apple, possibly on account of the fine hairs with which this fruit is covered when small. More of the eggs of the second generation, however, are placed on the fruit, which by this time is much larger and presents a comparatively

smooth surface. The average time required for the egg to hatch is about 11 days, the time varying considerably, however, with the temperature.

**The larva.**—It is in the larval or "worm" stage that injury is done to the apple. The larva as it hatches from the egg is very small, from one-twentieth to one-sixteenth of an inch in length, but it soon begins to search for the fruit. If hatched from eggs placed here and there on the foliage, the larvæ chew more or less into the leaf or other portions of the plant in their wandering around and may thus be poisoned, if poison be present on the plants. If the eggs have been deposited on the fruit itself the larvæ are much more likely to gain entrance to the fruit. Larvæ entering the fruit by the calyx end feed within the calyx cavity for a few days before penetrating the fruit. Hence the advantage of thoroughly spraying trees shortly after the petals have fallen and while the calyx lobes are still spread, in order to place in each calyx cavity a small particle of poison to be eaten later by the larva as it seeks to enter the fruit.

After entering the apple the larva feeds and grows rapidly and in the course of about 20 days has become full grown. (See fig. 2, *b*.) At this time the "worms" are about three-fourths of an inch long, and the majority of them are pinkish or flesh colored on the upper surface and whitish below.

**The pupa.**—The full-grown larva, upon leaving the fruit and finding a protected place, constructs a whitish silken cocoon within which, in the course of a few days, it may change to pupa, or it may remain in the larval condition until the following spring, as already explained. The pupa (fig. 2, *c*) is about one-half inch long, at first yellowish or brownish, but later becoming quite dark brown, and shortly before emergence of the moth assuming a distinct bronze color. The pupal stage varies much in length, but on the average about 20 days elapse from the spinning of the cocoon until the emergence of the moth. After emergence the moths, in the course of a few days, begin egg laying, the entire life cycle, from egg to egg, requiring, on the average, some 50 days.

## TREATMENT.

The treatment for the codling moth is limited almost entirely to spraying the trees with arsenicals, such as Paris green or arsenate of lead; the latter is now principally used. In the East the poison is usually combined with a fungicide. In some sections banding of trees is also employed and under special conditions is a valuable adjunct to spraying. From two to five spray applications are given, according to the section of country.

**First application.**—Of all treatments, the first is much the most important; this is given as soon as the blossoms have fallen and has

for its object the placing of poison in the calyx cup of each little apple. This treatment may be successfully given during the eight or ten days between the dropping of the petals and the closing of the calyx lobes. After the calyx lobes have drawn together it is difficult to force the poison into the calyx cup. (See fig. 3.) Very thorough work is necessary at this time, and carelessness in making the first application can not be counteracted by subsequent treatments. Good results, in fact, have been obtained where this application alone has been given; and in portions of the West, where it is unnecessary to spray for fungous diseases, a single treatment is held by some to be sufficient. While excellent results have been obtained in the East from this so-called "one-spray" method, yet

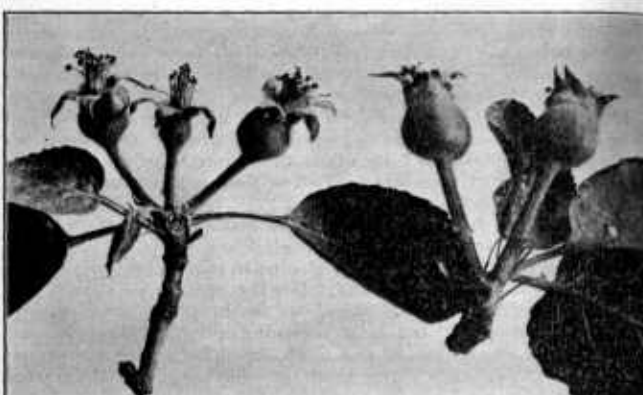

FIG. 3.—Apple clusters, showing, on the left, young fruit with calyx lobes spread, and in right condition for spraying; on the right, apples with calyx lobes closed, and too late for satisfactory spraying.

the necessity of using fungicides in this territory renders the use of arsenicals in addition comparatively inexpensive.[1]

**Second application.**—The second application for the codling moth is given from three to four weeks after the blossoms have fallen and has for its purpose the destruction of the young larvæ as they are hatching from the eggs spread promiscuously over the foliage and fruit.

**Third application.**—Eight or nine weeks following the dropping of the petals the third treatment is given, at which time the second-brood larvæ are hatching in numbers.

[1] Those interested in the one-spray method should obtain copies of Bulletin 80, Part VII, and Bulletin 115, Part II, Bureau of Entomology.

These three treatments, if properly applied, should be sufficient to control the insect effectively in any region; but in a territory where bitter rot and apple blotch are prevalent, and where later fungicidal treatments are necessary, it will be advisable to add an arsenical for further insurance against the codling moth, as stated under the caption "Spraying schedule," pages 43–44.

## THE PLUM CURCULIO.

The plum curculio (*Conotrachelus nenuphar* Herbst), over a great deal of its range, is easily second in importance as an apple pest to the codling moth. It occurs quite generally from Canada south to Florida and west to about the one-hundredth meridian. The insect is a small snout beetle, of the family Curculionidæ, and many of its near relatives, as the cotton-boll weevil, strawberry weevil, plum gouger, alfalfa weevil, etc., are very serious enemies of cultivated crops. The species attacks most cultivated pome and stone fruits, as apple, pear, peach, plum, cherry, etc., and it is especially troublesome to the peach.[1] In the present connection the insect is considered in reference to its injuries to apple.

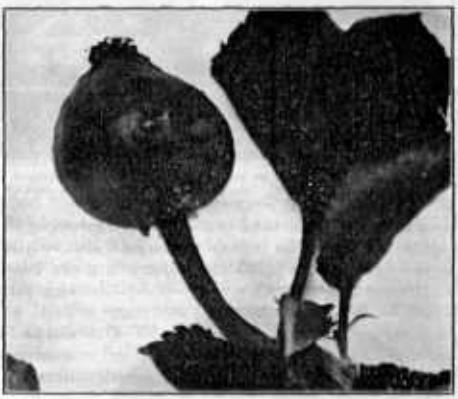

FIG. 4.—Egg scars of the plum curculio (*Conotrachelus nenuphar*) on young apples.

### CHARACTER OF INJURY.

The overwintering beetles attack the young apples in the spring, shortly after these are well set. Both sexes puncture the fruit with their snout-like proboscis for feeding, and the females also in egg laying. Feeding and egg laying continue for several weeks or months in the case of the hardier individuals. Much of the fruit, punctured while small, falls to the ground, but after it has become about the size of a large marble or larger (see fig. 4), it may remain

[1] See Farmers' Bulletin 440, U. S. Department of Agriculture, Spraying Peaches for the Control of Brown-rot, Scab, and Curculio.

on the trees. The effect of the punctures when abundant, however, is to cause the fruit to become knotty and misshapen as it grows, the extent of the deformity varying with the severity of the injury

FIG. 5.—Duchess apples at picking time, showing deformed condition from egg and feeding punctures of the plum curculio.

and also with the variety. Rapidly growing summer or fall varieties of apples show the injury perhaps worst, while in the case of slower-growing winter apples the injury is more likely to be outgrown, the egg punctures showing in the fall as more or less nail-shaped scars, not affecting the quality of the fruit, though detracting from its appearance. (See fig. 5, showing deformed Duchess apples.)

FIG. 6.—Fall feeding punctures of the plum curculio in ripe apple.

When beetles of the new generation appear in late summer and fall they feed upon the fruits, producing injuries shown in figure 6. With the snout a hole is excavated in the apple, and the flesh is eaten out under the skin surrounding the puncture as far as this organ will reach. This "fall" feeding puncture is often very much in evidence in orchards where the insect is abundant, and the injury is at times considerable. Decay of the fruit often starts at the injured place,

spreading from and enlarging the cavity, as shown in the figure, and soon rendering the fruit worthless, except for immediate use. Fruit thus punctured in the fall will not, as a rule, keep well in storage and should not, of course, be included in the best grades.

Although the curculio larva is able to develop on the trees in peaches, plums, and cherries, it does not appear to be able to do so in apples and pears. The larvæ, however, develop perfectly in apples which fall to the ground, and orchards are thus kept well stocked with the insect.

### PERIOD OF OVIPOSITION AND NUMBER OF EGGS LAID.

The adult beetles are out and ovipositing on plums and other early fruit before apples, as a rule, are of sufficient size to be used. As soon as the apple is grown to the size of a small marble, however, it is attacked by the curculio for egg-laying purposes, and most of the eggs are deposited during the first six or eight weeks after egg laying begins. A large number of records of the number of eggs deposited by the curculio in plums, peaches, apples, etc., has been obtained in different localities, as well as other data on the life and habits of the insect.

It has been found that the greatest number of eggs deposited by any one female was 557, and the minimum 1, with an average of 144.85 eggs per beetle for all the individuals under observation. While there is much variation in the number of eggs deposited within a given time in the several localities, there is a general agreement in that the great majority of the eggs are placed by the end of eight weeks; approximately one-fourth of the total eggs are deposited during the first two weeks; one-half have been deposited by the close of the first month; three-fourths within six weeks, and about 88 per cent of the total within eight weeks after oviposition began. The value of these data will appear when it is remembered that the injury to the apple results from the egg and feeding punctures, which it is desired to prevent. To accomplish this best, sprays must be applied with timeliness and be in effect over a considerable period.

### TIME REQUIRED FOR TRANSFORMATION FROM EGG TO ADULT.

Many observations have been made in different localities, which show the time spent in the fruit by the curculio larva, and also the time spent in the ground, before and during pupation, until the emergence of the beetle. Thus the average time spent in the fruit (egg and larval stages combined), for the several localities investigated, proved to be 19.48 days, and the average time spent in the ground (as larva, pupa, and adult) was found to be 30.89 days, giving an average life-cycle period for the insect of 50.27 days.

Complete observations of the life cycle have also been made on a total of 597 individuals from many parts of the country, which give a final average per individual of 50.71 days, differing only a fraction of a day from the time determined in an essentially different manner. Approximately 50 days would therefore appear to be the average life-cycle period for the plum curculio for the country as a whole. The variation for different individuals will be considerable, and as actually determined in the case of individual records was from 37 to 58.45 days.

For practical purposes there is only one generation of the beetles each year. The adults, developing from fruit during the summer, spend the remainder of the time, until hibernation begins, feeding upon the foliage and fruit. With the approach of cold weather the beetles seek shelter, apparently wherever they may be, under trash in orchards, along fences, and in similar places. They are always abundant in woods adjacent to orchards.

## CAN THE CURCULIO BE CONTROLLED BY SPRAYS?

During the past few years much experimental work has been done in the use of arsenical sprays in the control of the curculio on apple, notably by Prof. Stedman in Missouri and Prof. Crandall in Illinois. Prof. Crandall's investigations extended over two years. In regard to the value of the work he states as follows:

> To sum up the matter of spraying for the curculio from the standpoint of results obtained during the two seasons of 1903 and 1904, it seems possible, under favorable conditions and with a reasonable number of applications, to control curculios to the extent of from 20 to 40 per cent of the possible injury. There is benefit to be derived from spraying, but not that degree of benefit which would warrant commendation of spraying as the one great panacea of injury done by the curculio.

Many experiments by the Bureau of Entomology emphasize in general the soundness of the conclusions of Prof. Crandall. In the following table are given results of spraying for the curculio on apple as carried out by the Bureau of Entomology in different parts of the country.

TABLE I.—*Results of spraying apples for the plum curculio—various localities.*

| Locality. | Treatment. | Number of sound apples. | Number of apples punctured. | Total number of apples. | Average percentage of sound apples. | Number of applications. |
|---|---|---|---|---|---|---|
| Anderson, Mo., 1908 | Bordeaux mixture (4-4-50) plus ½ pound Paris green. | 1,710 | 1,867 | 3,577 | 47.81 | 7 |
| Do | Bordeaux mixture (4-4-50) plus 2 pounds arsenate of lead. | 3,844 | 2,846 | 6,690 | 57.45 | 7 |
| Do | Untreated | 193 | 3,312 | 3,505 | 5.51 | None. |
| Westfield, N. Y., 1908 | Bordeaux mixture (4-4-50) plus 2 pounds arsenate of lead. | 10,506 | 921 | 11,427 | 91.07 | 4 |
| Do | Untreated | 300 | 761 | 1,061 | 28.44 | None. |
| North East, Pa., 1906 | Bordeaux mixture (4-4-50) plus 2 pounds arsenate of lead. | 1,354 | 359 | 1,713 | 79.04 | 2 |
| Do | Untreated | 270 | 791 | 1,061 | 25.44 | None. |
| Siloam Springs, Ark., 1909. | Bordeaux mixture (4-4-50) plus 1 pound arsenate of lead. Trees drenched. | 37,304 | 5,899 | 43,203 | 80.34 | 1 |
| Do | Bordeaux mixture (3-3-50) plus 2 pounds arsenate of lead. | 26,897 | 5,554 | 32,451 | 82.88 | 5 |
| Do | Untreated | 2,234 | 22,212 | 24,446 | 9.14 | None. |
| Crozet, Va., 1909 | Bordeaux mixture (2-2-50) plus 2 pounds arsenate of lead. Trees drenched. | 15,406 | 5,432 | 20,838 | 73.93 | 1 |
| Do | Bordeaux mixture (2-2-50) plus 2 pounds arsenate of lead. | 12,231 | 1,846 | 14,077 | 86.89 | 4 |
| Do | Untreated | 10,322 | 8,785 | 19,107 | | None. |
| Mount Jackson, Va., 1909. | Bordeaux mixture (2-2-50) plus 2 pounds arsenate of lead. Trees drenched. | 11,335 | 8,240 | 19,575 | 57.90 | 1 |
| Do | Bordeaux mixture (1-1-50) plus 2 pounds arsenate of lead. | 6,651 | 9,642 | 16,293 | 40.82 | 3 |
| Do | Untreated | 6,984 | 18,657 | 25,641 | 27.23 | None. |
| St. Joseph, Mo., 1909 | Arsenate of lead, 2 pounds to 50 gallons of water. Trees drenched. | 2,130 | 3,658 | 5,788 | 36.80 | 1 |
| Do | Bordeaux mixture (4-4-50) plus 2 pounds arsenate of lead. | 2,480 | 2,470 | 4,950 | 50.10 | 4 |
| Do | Untreated | 182 | 4,307 | 4,489 | 4.05 | None. |

It will be noted that the results of spraying vary widely. It is apparent that account must be taken of other conditions, such as the relative abundance of the insects as compared with the amount of fruit present on the trees. With a small fruit crop and an abundance of curculios the most thorough spraying will not serve to bring through a satisfactory amount of sound fruit, as will be noted in the results of experiments at St. Joseph, Mo. With a large crop of fruit and an abundance of insects, results will likewise be disappointing; note the results at Mount Jackson, Va. If the curculios for any cause are scarce, and there is a large fruit crop, injury is, of course, much less important. In other words, the degree of success in spraying varies with the abundance of the insects. While spraying is undoubtedly a most important adjunct, and if persisted in from year to year may answer reasonably for its control, yet it is clear that where the insect is abundant other measures should also be employed. In all cases which have come under our observations the insects have always been found most abundant in orchards which are in sod or are poorly

cared for and allowed to grow up more or less in weeds and trash. Orchards adjacent to woods will also usually suffer severely, especially along the border. As opposed to this condition is the notably less injury in orchards kept free from weeds and trash. In such cases the sprayings usually given for other orchard insects, as the codling moth, serve to keep the curculio well under control. In fact, it may be said as a general statement that this insect will never become seriously troublesome in apple orchards given the usual routine attention in cultivation, spraying, pruning, etc., now considered essential in successful fruit growing.

## THE LESSER APPLE WORM.

The larva of the lesser apple worm (*Enarmonia prunivora* Walsh) and its work have been quite generally confused with those of the codling moth. The caterpillar when full grown is about one-half the size of the full-grown codling-moth larva, and is fusiform in shape and usually pink or flesh colored. A codling-moth larva of this size is rarely, if ever, pinkish in color, but dirty white, and marked with black dots. The injuries of the two species are in a way quite similar. The first-brood larvæ of the lesser apple worm enter the fruit mostly at the calyx end. Cavities or holes from one-fourth to one-half inch deep are eaten into the flesh, more or less around the calyx lobes and core within. The larvæ, boring directly through the skin at the base of the calyx lobes, or, more commonly, entering the calyx cavity, excavate mines or short burrows down into the flesh. Frequently also the larvæ burrow out in the calyx basin just under the skin, producing winding or blotch mines (see fig. 7). Such mines occur on the sides of the apple, especially where two fruits are in contact. Young fruit thus injured usually falls or ripens prematurely. Later in the season the calyx-end injury is about as described, though the surface injury is more common, the larvæ eating out the flesh under the skin in large, irregular, more or less linear patches, which are quite conspicuous. Larvæ of this species apparently do

FIG. 7.—Injury by the lesser apple worm (*Enarmonia prunivora*) in calyx basin and end of a ripe apple.

not reach full development as early in the fall as those of the codling moth, and may find their way to barrels with the fruit, where they continue to feed, often doing considerable damage. Figure 8 illustrates apples thus injured, as found in barrels on the Washington market.

The lesser apple worm is probably a native insect, and it infests other fruits, wild and cultivated. It is recorded from apples, haws, plums, prunes, cherries, peaches, and species of Cratægus. It has also been reared from the black-knot of plum, and from galls on oak and elm.

Its life history and habits probably closely parallel those of the codling moth. It is known to be present quite generally in orchards from Canada south to Georgia and west to the Rocky Mountains. It

FIG. 8.—Injury by lesser apple worms to apples after barreling.

has been found abundantly in apples in the Puget Sound district in Washington, and is known also from British Columbia.

The schedule of treatments recommended for the codling moth will be effective in the control of this species.

## CANKERWORMS.

Two species of cankerworms in the United States are often destructive pests in apple orchards, the larvæ making their appearance shortly after the leaves have put forth. The caterpillars (fig. 9) are rather small, slender, naked creatures with the habit of looping as they crawl, for which reason insects of this habit are commonly designated as "span worms" or "measuring worms." The fall cankerworm (*Alsophila pometaria* Harris) occurs more commonly in the northern United States, as from Rhode Island to Canada and

westward to Lake Superior, and it is also common in California. The spring cankerworm (*Paleacrita vernata* Peck) is particularly abundant in the Mississippi Valley from Texas to Iowa, ranging eastward to Maine. It is common in the orchard section of northern Virginia, western Maryland, and West Virginia. The two species thus overlap in their distribution and both may be concerned in the defoliation of an orchard, especially in the northeastern part of the United States.

The fall cankerworm deposits its eggs in ringlike masses on the twigs during late fall or in warm periods during the winter. The spring cankerworm oviposits in early spring, before the buds start, in irregular masses under bark scales, along the trunk and limbs,

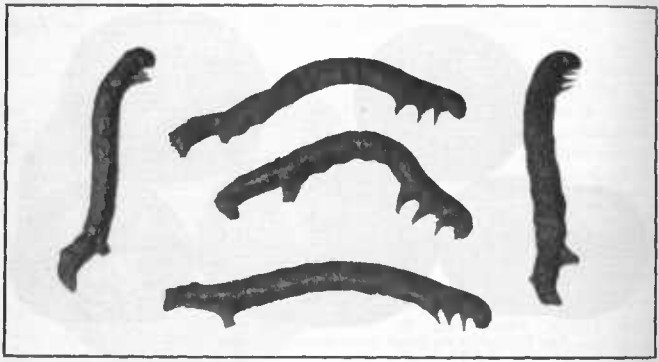

FIG. 9.—Spring cankerworms. Enlarged.

or more or less promiscuously. The young larvæ have hatched and are attacking the foliage by the time the young leaves are well free from the bud scales. They often occur in such enormous numbers that the trees are quickly defoliated, leaving only the midribs of the leaves (see fig. 10), the orchard from a distance appearing as if swept by fire. After the larvæ mature they go to the ground and pupate just below the surface, and are easily destroyed by plowing and cultivations during the late spring and early midsummer. There is only one generation of the insects each year, the adults of the fall species coming out in late fall and winter, and those of the spring species in early spring, as stated. The adult females of both species are wingless and must crawl up the trunks of the trees to oviposit.

## TREATMENT.

Three methods of control are applicable against cankerworms, and where the insects have been quite injurious the use of all three methods in conjunction may be adopted.

The wingless moths, and also the caterpillars, may be prevented to a large extent from reaching the foliage by the use of bands of sticky substances around the trunks of trees, some 12 to 18 inches from the ground. Some excellent preparations for this purpose are on the market, or home-made adhesives may be used. A simple plan is first to scrape off the rough bark from the trunk of the tree in a band 8 to 10 inches high, and surround the tree at this place with a strip of stiff paper, tying tightly, so that no moth or larva can work up the trunk beneath it. The paper band should then be coated with a sticky adhesive, which should be replenished as often as necessary to keep it in good working condition. This method is especially suited to large trees in lawns around the home, or elsewhere, where plowing and spraying are considered impracticable.

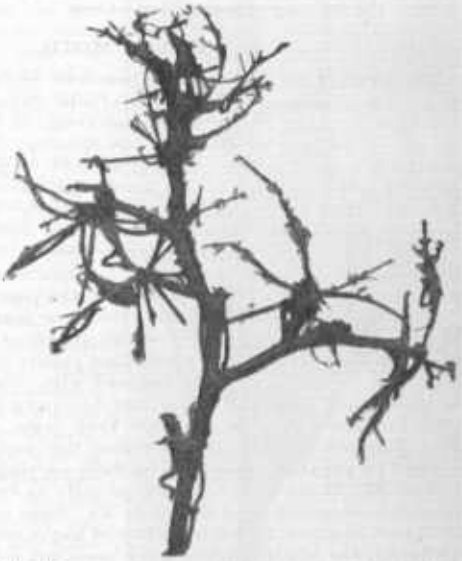

FIG. 10.—Work of the spring cankerworm (*Paleacrita vernata*) on apple.

The larvæ are readily poisoned with arsenicals, as arsenate of lead and Paris green, used at usual strengths. The first treatment for apple scab, while a little late for cankerworms, will in most cases answer fairly well, and where the insect is troublesome an arsenical should be added, as for the bud moth.

Plowing orchards during late spring and early summer, with a few subsequent cultivations, will destroy most of the pupæ in the soil. Care should be taken to stir the soil beneath the spread of the limbs of the trees, as in this soil most of the pupæ are located.

Except during very unusual conditions of abundance, orchards properly sprayed and cultivated will not be troubled by these insects. Canker worms thrive in neglected old orchards in sod, and may appear for several seasons in succession, and by devouring the leaves destroy the fruiting capacity of the trees.

## THE BUD MOTH.

The larva of the bud moth (*Tmetocera ocellana* Schiff.) winters in a little hibernaculum or cocoon of silk covered with bits of dirt and bark attached to the limbs and twigs of trees. Early in the spring, as the buds of the apple are opening, the little dark-brown caterpillars, scarcely one-fourth of an inch long, leave their winter quarters and attack the tender developing leaves, often boring into the bud before the scales have spread apart. When abundant the larvæ are thus able to do a large amount of injury. Severe damage may result to nursery stock or young trees following attack on the terminal buds of twigs or shoots. In some cases the twig itself is penetrated, the larva boring down into the pith some 2 or 3 inches.

After their appearance in spring the larvæ continue to feed, mostly at night, for some six or seven weeks, attacking principally the leaf and fruit buds. When full grown they pupate in a tubular fold of a leaf, well lined and securely fastened with silken threads; or two or three partly devoured leaves may be drawn together and within these the cocoon is made. In New York State, and probably in the New England States, in which region this pest is frequently complained of, pupation takes place on dates varying from about June 1 to June 25. Moths begin to emerge as early as June 5, and emergence continues somewhat later than July 10. Eggs are deposited for the most part singly on the lower surface of leaves and hatch in from 7 to 10 days. The newly hatched larvæ construct a tube along the midrib or larger vein of a leaf, from which they emerge to feed on the adjacent tissues, spinning as they go a web of silk for their protection. Feeding continues during July and August, and a few are thus engaged in September, when, deserting the foliage, hibernacula are constructed, as described, in which the half-grown larvæ remain until the following spring, attacking the buds as stated. The principal injury results from the attack to the unfolding buds and to the twigs in the spring, although in neglected orchards considerable injury to foliage may result from the feeding of the young larvæ during midsummer. In more northern latitudes the bud moth is

single-brooded, though in the central and more southern States it is thought that there may be two broods of larvæ each year.

### TREATMENT.

The control of the bud moth rarely requires treatments other than those given in the course of spraying adopted by progressive orchardists. The first treatment for the apple scab coincides fairly well with the time when these larvæ are actively feeding in the spring, and where their injury has been noted or is suspected an arsenical should be added to the fungicide used. The spray application after the falling of the blossoms, constituting the first treatment for the codling moth, is effective in further reducing the bud moth, and the two treatments should, under ordinary conditions, be sufficient to keep it well reduced.

FIG. 11.—Nest and larvæ of the apple-tree tent caterpillar (*Malacosoma americana*).

## THE APPLE-TREE TENT CATERPILLAR.

The conspicuous, unsightly nests or tents of the apple-tree tent caterpillar (*Malacosoma americana* Fab.) are not often seen in well-cared-for orchards, as this insect is kept well in check by the usual applications of arsenical sprays for the codling moth, curculio, etc. The nests, however, are often in evidence in neglected orchards and in trees along roadsides, and indicate a lack of interest on the part of the landowner in his orchard crops.

The insect winters in the egg stage, the eggs being placed on twigs in a ringlike mass. The young larvæ appear as the foliage is pushing out in the spring and at once start their nest in the crotch of some limb or branch, in which they retreat for protection when not feeding. As the caterpillars grow the nest increases in size, until by the time the insects are full grown, it is a conspicuous, unsightly object. (See Fig. 11.)

### TREATMENT.

As stated, orchards well sprayed for other fruit pests will rarely be seriously troubled by the tent caterpillar. Nevertheless the insect during certain seasons may become unusually abundant and special treatments may be necessary for its control. The destruction of the nests themselves and the contained caterpillars is comparatively easy. Where the nests are low down on the tree it will be practical to destroy them by hand, or, if the nests are out of reach, they may be destroyed by means of some form of torch on a pole, the torch being made of asbestos or other absorbent material saturated with an inflammable oil, such as kerosene or crude petroleum.

FIG. 12.—Baldwin apple badly infested with the San Jose scale (*Aspidiotus perniciosus*).

### THE SAN JOSE SCALE.

The use of dilute lime-sulphur sprays as fungicides on trees in foliage appears to have a distinctly retarding effect on the development of the San Jose scale. While all orchards infested with this insect should be given the usual dormant tree treatment, for one reason or another considerable numbers of the scale may escape destruction, especially on the terminal twigs, which are more difficult to coat thoroughly with the wash. The scales which thus escape are usually so few in number that no serious damage results during the season to the twigs and branches, but the young "lice" have a tendency to crawl out and settle on the fruit, thereby greatly disfiguring it. (See Fig. 12.) The presence of these scales is very objectionable on apples intended for export trade, as scale-infested fruit is excluded from entry by certain foreign governments, and is discriminated against by buyers generally. The following data (Table II) on the effect of sulphur sprays in lessening scale infestation of the fruit were obtained by Mr. E. W. Scott,

of the Bureau of Entomology, in the course of some experimental work during 1911, at Fennville, Mich.:

TABLE II.—*Results of lime-sulphur sprays in preventing marking of fruit by the San Jose scale.*

| Plat No. | Treatments.[1] | Variety. | Number of apples infested. | Number of apples not infested. | Total number of apples. | Percentage of uninfested apples. |
|---|---|---|---|---|---|---|
| 1 | Commercial lime sulphur, 1¼ to 50; sprayed May 12, 25, June 14, July 25. | Rhode Island Greening. | 137 | 1,606 | 1,743 | 92.13 |
| 2 | .....do..... | Baldwin..... | 80 | 778 | 858 | 90.67 |
| 3 | Home boiled lime sulphur, May 12,25, June 14, July 25. | Greening..... | 79 | 3,939 | 4,018 | 98.03 |
| 4 | .....do..... | Baldwin..... | 37 | 1,813 | 1,850 | 98.00 |
| 5 | Commercial lime sulphur, 1¼ to 50; May 12, 25, June 14, July 25. | .....do..... | 13 | 298 | 311 | 95.81 |
| 6 | Bordeaux mixture (3–4–50), May 12, 25, June 14, July 25. | Greening..... | 843 | 1,055 | 1,898 | 55.58 |
| 7 | .....do..... | Baldwin..... | 525 | 500 | 1,025 | 48.78 |
| 8 | Unsprayed..... | Greening..... | 798 | 805 | 1,601 | 50.28 |
| 9 | .....do..... | Baldwin..... | 809 | 190 | 999 | 19.01 |

[1] All treatments had 2 pounds of arsenate of lead to each 50 gallons of spray, except in case of plat 5, which had the poison in the application of May 12 only.

The influence of the sulphur sprays in checking the settling of the young scales on the fruit is here very marked and furnishes an added reason for the use of sulphur sprays as fungicides.

## APPLE SCAB.

### ECONOMIC IMPORTANCE.

Apple scab is a fungous disease of the fruit and foliage of the apple and ranks as the most destructive disease to which this fruit is subject. In unsprayed orchards it often causes the loss of 50 to 75 per cent of the crop, and not infrequently the entire crop of certain varieties is rendered unfit for market by the deformed, cracked, and unsightly condition produced by the fungus. Affected fruit is usually small, unsightly, often cracked, and does not keep well. However, since the practice of spraying has become general among apple growers this condition has been largely relieved.

### DISTRIBUTION.

Apple scab is common practically wherever the apple is grown—in America, Europe, Australia, New Zealand, and elsewhere. However, it is essentially, a cool-climate disease, and in the United States it is most destructive in New England, the Middle Atlantic States, the Great Lakes region, the Mississippi and Ohio Valleys, and portions of the Pacific Northwest. In the Southern States it is not a serious pest, except on the higher elevations, and then only on very susceptible varieties.

## CHARACTER OF THE INJURY.

The fungus causing apple scab attacks the fruit, foliage, and to a much less extent the twig. The greatest damage is done to the fruit, on which it produces the scabby spots familiar to most apple growers. These spots are circular, though somewhat irregular, in outline, dark gray or olivaceous in color, becoming blackish with age, and they range in size from mere specks to spots one-fourth inch or sometimes one-half inch in diameter. (See fig. 13.) The fungus ruptures the epidermis of the apple, forming a gray, jagged ring at the border of the healthy tissues. Two or more spots may coalesce, forming a large scabby area, in some cases covering one side of the apple. The disease prevents the normal development of the fruit, the affected side becoming dwarfed, pitted, and otherwise deformed. It also causes the development of cracks, which may extend half

FIG. 13.—Apples affected with the scab fungus, the one on the left showing characteristic spots and the one on the right smaller spots with crack.

way around the apple and almost to the core. A large percentage of the affected fruit drops to the ground before maturing.

In a cool, wet spring the blossom buds and young fruits in blossom may be attacked and destroyed. Occasionally, though rarely, the entire crop of an important fruit section may be destroyed in this manner.

The disease occurs on both sides of the leaves, forming smoke-brown or olivaceous patches which become swollen and blisterlike. (See fig. 14.) The affected leaves often curl somewhat and may drop prematurely. The fungus is said to occur also on the twigs, forming blackish-olive patches, but this is apparently not common in the United States.

## THE FUNGUS CAUSING THE DISEASE.

Apple scab is caused by a fungus known as *Venturia pomi* (Fr.) Wint., which lives over winter in the fallen apple leaves. In the spring, when the weather becomes warm enough to start apple trees

into growth, the fungus becomes active, producing large numbers of spores, which are discharged into the air and carried to the young leaves, blossom buds, and later to the young fruit. If there is sufficient moisture present these spores germinate, producing infections that develop into the characteristic scab spots. Summer spores are soon produced on these spots, and through them the fungus may readily spread to other fruits and leaves.

The period of greatest infection is from the time the first apple leaves appear until about four weeks after blooming. The fungus thrives best in cool, moist weather, such as is likely to occur during this period. Hot weather is very unfavorable to it, and infections rarely take place after summer sets in. However, in the New England States a second infection period sometimes occurs during September, and from these late infections small scab spots may develop after the fruit is picked and stored.

FIG. 14.—The scab fungus on apple leaf.

## TREATMENT.

Scab was one of the first apple diseases to receive attention by investigators, and its successful treatment was worked out as early as 1891. Until quite recently spraying with Bordeaux mixture constituted the remedy for it, but owing to the injurious effect on both fruit and foliage produced by this otherwise excellent fungicide, especially during wet seasons, dilute lime-sulphur solution is rapidly coming into use as a substitute for it. Lime-sulphur solution has about the same fungicidal value as Bordeaux mixture in the treatment of apple scab and produces decidedly less injury to fruit and foliage.

Lime-sulphur solution may be purchased from several manufacturers or it may be prepared at home. (See pp. 38–40.) Taking a solution that registers 32° on the Baumé hydrometer as a standard, the strength to use in spraying for scab is 1¾ or 1½ gallons to each 50 gallons of water. On varieties seriously attacked by scab and in localities where the disease thrives the greater strength should be used, but in order to reduce the danger of injury to a minimum the weaker spray should be used where only slight outbreaks of scab are expected. Arsenate of lead at the rate of 2 pounds to each 50 gallons

of solution should be added to control the codling moth, curculio, and other insects.

Spray the trees (1) when the cluster buds open, just before blooming; (2) as soon as the petals fall; and (3) two or three weeks later. Varieties only slightly affected by scab, especially in the South, do not require the first application of this series, the two sprayings after the petals fall being sufficient to prevent the disease. On the other hand, in New England an extra application about the middle of August may be required to prevent late scab infections on some very susceptible varieties.

## BITTER ROT.

### ECONOMIC IMPORTANCE.

In sections where it is prevalent bitter rot is the most dreaded of all the common apple diseases. After the fruit has been safely nursed through the attacks of scab and the codling moth and is about ready to be harvested an outbreak of bitter rot may destroy the entire crop of some varieties without much warning. It is rather spasmodic in its appearance, depending largely on weather conditions. Hot weather with plenty of moisture is essential to the rapid development of the disease, and it therefore does not occur to any serious extent in the more northern parts of the apple belt nor in the drier sections of the West. It is well distributed throughout the Southern States where apples are grown, extending into southern Illinois, and has in the past destroyed several million dollars worth of apples during a single season. However, in recent years, since its treatment has been better understood and more thoroughly put into practice, the annual losses have not been so great.

FIG. 15.—Apple affected with bitter rot.

### CHARACTER OF THE INJURY.

The bitter-rot disease appears on the fruit as a circular brown spot with concentric rings of fruiting pustules. (See fig. 15.) The

young spots are very small and often show purplish or reddish margins, but under favorable conditions they rapidly enlarge, involving the entire apple in decay. The disease extends inward toward the core at about the same rate as the spread on the surface, forming a cone-shaped area which can be easily crushed out with the fingers. Owing to the shrinking of the invaded tissues, the spots become somewhat sunken, and this distinguishes it from black rot and brown rot. Several spots, or, in severe cases, several hundred spots, may occur on the same apple, although one spot is sufficient to destroy the whole fruit.

### CAUSE OF THE DISEASE.

Bitter rot is caused by the fungus *Glomerella rufomaculans* (Berk.) Spauld. and Shrenk, which invades the tissues of the apple, producing the familiar spots described above. It passes the winter in cankers on the limbs and in mummied fruits. Under favorable weather conditions spores from these sources and perhaps from unknown sources infect the fruit, starting an outbreak of bitter rot. When the germ tube, resulting from the germination of a spore, finds its way through the skin of the apple, it immediately begins to branch and grow rapidly, obtaining its food supply from the tissues and causing these to die and turn brown. After a time clusters or tufts of fruiting branches are formed and these burst through the skin in rings, producing pink masses of spores which serve to spread the disease to other apples. Millions of spores are produced from a single spot, so that under favorable conditions the entire crop of an orchard may become diseased from one center of infection.

In addition to the summer spores or conidia, there are produced on the mummied fruits and in limb cankers winter spores or ascospores, which constitute the perfect stage of the fungus. It is not definitely known that these ascospores play any important part in the life history of the fungus.

### THE LIMITING FACTORS.

Barring preventive measures, the two limiting factors determining bitter-rot outbreaks are weather conditions and varietal resistance. Heat and moisture are essential to the vigorous growth of the fungus, and of these two heat is the more important. While hot, showery, or muggy weather is ideal for the development of the fungus, serious outbreaks of the disease may occur during comparatively dry weather, provided the temperature is high and the dews are heavy at night.

Infections may take place at any time during July, August, and September, but rarely earlier or later. High summer temperatures are required for the rapid growth of the fungus, and these are the

months in which such temperatures usually occur. Infections may begin to take place during the latter part of June if the weather conditions are right, but since the fungus does not thrive on young, green fruits, no serious outbreak need be feared until July. Owing to climatic influence the bitter-rot disease is confined mainly to the southern tier of apple-growing States.

The second limiting factor, namely, varietal resistance, varies in different sections of the country. For example, the Yellow Newtown in Virginia is very susceptible to the disease, and under favorable conditions the entire crop may be destroyed, while the Ben Davis in the same orchard will become only slightly, or not at all, affected. On the other hand, the Ben Davis, in portions of the Middle West—southern Illinois, southern Missouri, and northwestern Arkansas—is one of the most susceptible varieties. This would indicate that there are two strains of the fungus, the Ben Davis being susceptible to the one occurring in the West and resistant to the one occurring in Virginia.

The most susceptible varieties grown in bitter-rot sections are Yellow Newtown, Willow, Huntsman, Smokehouse, Stark, Jonathan, Ben Davis, and many other less prominent varieties.

### TREATMENT.

Although it has been abundantly demonstrated that bitter rot can be readily controlled, even under the most severe conditions, many apple growers look upon it as the most treacherous of all the diseases with which they have to contend. The chief reason for this is the irregularity with which the disease appears. One year an outbreak may occur in July, while the next year the disease may not appear until September. Varieties partly resistant to the disease may go through several seasons without becoming affected, but when there comes a season unusually favorable to the fungus, much of the fruit of these varieties may be destroyed by the disease. This erratic habit of the disease keeps the apple grower in doubt as to when to expect it and when to spray. He does not care to give his orchard three or four bitter-rot sprayings when there is no bitter rot to fight, and he is loath to begin the treatment in June if the disease does not occur until September, yet the only safe plan in bitter-rot districts is to expect the disease every year and to keep the fruit protected from the latter part of June until the end of September.

Bordeaux mixture is still the best fungicide to use for bitter rot, the lime-sulphur solution having proved only partially effective against this disease. Fortunately Bordeaux mixture has very little or no injurious effect on the apple after the young fruits have attained an age of 6 or 8 weeks, and may therefore be used for bitter rot with comparative safety.

As to strength, the mixture should be used as weak as is consistent with good results in order to avoid as much as possible leaving a stain on the ripe fruit. A mixture composed of 3 pounds of bluestone and 4 pounds of lime to each 50 gallons of water, if properly applied, is sufficient for ordinary bitter-rot treatment; but the very susceptible varieties in districts where the disease is common should be sprayed with a stronger mixture, composed of 4 pounds of bluestone and 4 pounds of lime to 50 gallons of water.

In order to protect the fruit throughout the possible bitter-rot infection period the trees should be sprayed four times at intervals of two to three weeks, beginning seven to eight weeks after the petals have been shed. In the bitter-rot belt the dates of the application would be about as follows, though varying somewhat with the season: (1) June 25–30, (2) July 10–15, (3) July 25–31, and (4) August 10–15. Such a course of treatment, properly carried out, will secure protection against outbreaks of bitter rot under the most adverse conditions. By observing the weather conditions and watching for the first infections the first application may be delayed a few days and the intervals lengthened so that three sprayings can be made to do the work. With very susceptible varieties this is risky, but with varieties only moderately susceptible three sprayings are sufficient.

The removal of cankered limbs and the destruction of bitter-rot mummies doubtless help to control the disease, and should be practiced, but these precautions can not take the place of spraying.

For the control of the second brood of the codling moth arsenate of lead at the rate of 2 pounds to each 50 gallons of Bordeaux mixture should be used in the second and third bitter-rot sprayings.

## APPLE BLOTCH.

Apple blotch may be considered the scab disease of the South, its effect on the fruit being very similar to that of apple scab. It is well distributed over the southern half of the apple belt, beginning approximately where apple scab leaves off, although there is considerable overlapping of the two diseases at some points. At present the disease is most destructive in Kansas, Oklahoma, Arkansas, Missouri, Kentucky, and southern Illinois. The destruction of half the crop of certain varieties is not an infrequent occurrence in some of these badly affected districts. The disease occurs on the fruit, twigs, and leaves, but the principal damage is done to the fruit.

### CHARACTER OF THE INJURY.

**On the fruit.**—Apple blotch appears on the fruit as a hard brown spot with a roughened surface and a somewhat jagged margin. The blotch or spot is at first very small and light brown in color, but it

gradually enlarges, finally attaining a size of one-fourth or sometimes one-half inch in diameter. (See fig. 16.) The advancing margin usually has a fringed appearance, and the surface is dotted with minute, black, raised dots known as pycnidia.

The spots may become so numerous as practically to cover one side of the apple, causing it to ripen and drop prematurely. They are usually accompanied by a cracking of the fruit, thus opening the way for other fungi and insects as well. Some of these cracks are very small, while others are half an inch or more in length. The appearance of affected fruit is so marred as to render it practically unfit for market.

**On the twigs.**—The fungus causing apple blotch attacks the twigs, fruit spurs, and "water sprouts," producing small brown cankers with purplish margins. These cankers are usually only about one-fourth by one-half inch in size, but may become considerably larger and often girdle the affected twig. With age the bark over the diseased area becomes cracked and scales up, giving the canker a rough appearance. These cankers as a rule do no serious damage to the tree, but the fungus passes the winter in them and they thus become a dangerous source of infection for the new fruit crop.

FIG. 16.—Maiden Blush apple affected with apple blotch.

**On the leaves.**—The leaves also become affected and here the disease manifests itself in the form of very small light-brown or yellowish spots. These spots are angular in outline and attain a size of only about one-sixteenth of an inch in diameter. The spots are usually very numerous on leaves of trees affected with the twig cankers, but they are so small that the injury produced is not often serious.

## CAUSE OF THE DISEASE.

Apple blotch is caused by the fungus *Phyllosticta solitaria* E. & E. The fungus lives over winter in the twig cankers, where it is perennial, and in the spring produces spores which ooze out in great numbers from little black raised points or pycnidia. These spores are carried to the fruit by rains, wind, and perhaps insects. Upon germination in the presence of moisture they throw out one or two fungous threads, which penetrate the skin, become much branched, and grow slowly in a radial manner, finally producing the brown blotches.

On the young spots the fungus growing underneath produces small black receptacles in which spores are borne. These spores, when discharged, may infect other fruits, leaves, and twigs.

### INFECTION PERIOD.

The fungus in the twig cankers becomes active about the time the apple trees bloom, and about four weeks later fresh spores are produced, ready to infect the fruit and leaves. If the weather conditions are favorable, infections, therefore, begin to take place from four to five weeks after the petals fall. Infections may continue to take place for several weeks, but as a rule the chief damage to the fruit crop results from the infections occurring within six weeks after the petals fall. Spraying for its control should, therefore, be done in time to protect the fruit from these early infections. The fungus is a slow grower and the spots may not show up until two or three weeks have elapsed after infections have taken place, so that to begin spraying when the first spots appear would be much too late to prevent the disease.

### TREATMENT.

Unfortunately the lime-sulphur sprays have not proved entirely satisfactory for the control of apple blotch. In orchards where the disease is not very serious lime-sulphur solution may be used with good results, but for the present at least the chief reliance for the prevention of the disease should be placed on Bordeaux mixture. Lime-sulphur solution should be used with the first codling-moth spray as soon as the petals fall, thus avoiding a part of the danger of spray russet, and Bordeaux mixture should be used in the subsequent applications. The spraying schedule for bad cases of apple blotch should be about as follows: (1) Lime-sulphur solution as soon as the petals fall; (2) Bordeaux mixture three weeks later; (3) Bordeaux mixture six weeks after the petals fall; and (4) Bordeaux mixture nine weeks after the petals fall. In a dry season the third treatment may be omitted, and in mild cases lime-sulphur solution may be used in all the applications. For the control of the codling moth and curculio, arsenate of lead should be added to the first, second, and fourth treatments.

## CEDAR RUST.

Cedar rust, also known as orange rust, is a disease affecting both fruit and foliage of the apple, quince, and other pomaceous plants. It is common in practicaly all the apple-growing districts east of the Rocky Mountains, causing considerable damage to certain varieties of apples. In some sections the disease is troublesome nearly

every year, but as a rule destructive outbreaks occur at rather wide intervals, depending upon weather and other conditions. Since the fungus causing the disease passes the winter on cedar trees and infection can take place only with spores from that source, the disease is confined to localities where the red cedar occurs.

### CHARACTER OF THE INJURY.

On the leaves the cedar rust disease manifests itself at first as minute, pale-yellow spots, which slowly enlarge, finally attaining

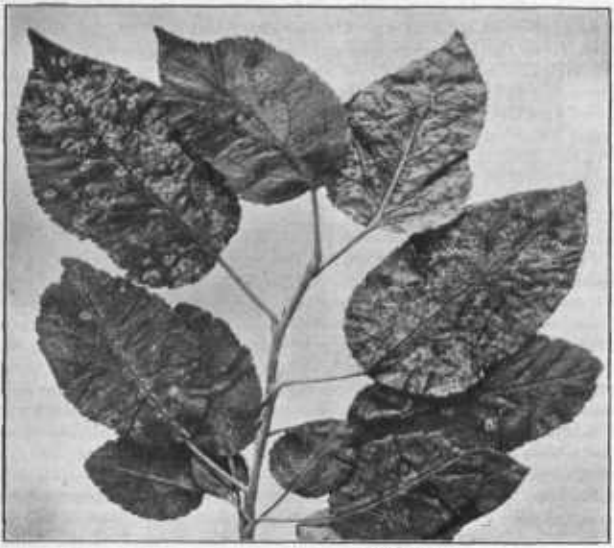

FIG. 17.—Foliage of York Imperial apple affected with cedar rust.

one-eighth to one-fourth inch in diameter and becoming orange-colored, with small black dots in the center. (See fig. 17.) Some time later, on the under side of the leaf beneath each spot the tissues become swollen, forming a blister or cushion on which cup-shaped spore receptacles are produced. These cluster cups are small tubular projections with fringed margins.

When only a small percentage of leaves is affected, as is frequently the case, no noticeable damage results, but susceptible varieties adja-

cent to cedar trees may become so badly affected that the trees appear yellowish, even from a distance. In such cases the function of the leaves is so interfered with that the fruit, the buds for the following year, and the tree itself are not properly nourished. This results in small, immature, poorly colored fruit, as well as weak buds and a weakened condition of the tree. Badly affected leaves usually drop prematurely.

Cedar rust appears on the fruit of the apple as bright yellow spots about one-half inch in diameter or sometimes larger. Both the black dots and the cluster cups occur on the spots, the latter usually forming one or more rings near the margin. (See fig. 18.) The spots may occur at any point on the fruit, but they are most frequently found near the blossom end. In severe cases the affected fruit may become deformed or atrophied, but as a rule there is no disfiguration other than the presence of the yellow spot. The market value of affected fruit is naturally reduced, much of it being discarded as culls. The disease on the fruit is not so important as that on the foliage, the greater damage being caused by the latter.

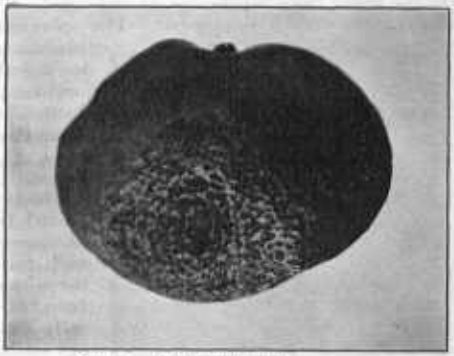

FIG. 18.—Cedar rust disease on the apple.

## LIFE HISTORY OF THE CEDAR-RUST FUNGUS.

There are several different species of rust fungi which pass a part of their existence on the red cedar and are obliged to spend the remainder upon the apple or some other pomaceous plant. Perhaps the most common of these is the one known as *Gymnosporangium juniperi-virginianæ* Schw. The spores produced in cluster cups which occur on the diseased leaves and fruit of the apple are carried by the wind to the red cedar trees, infecting the twigs of the latter and thus producing the well-known "cedar apples." (See fig. 19.) These are reddish-brown, globular swellings ranging in size from one-fourth to 1 inch or more in diameter when mature. The fungus thus established on the cedar passes the winter and develops during the follow-

ing summer, enlarging the gall, and finally during the second spring throws out long, yellowish, gelatinous projections in which spores are borne. These spores, while still in the gelatinous mass, germinate, producing a short fungus growth which bears a crop of smaller secondary spores. When the yellowish mass dries these secondary spores are carried like dust particles on the wind and when lodged on the fruit or foliage of the apple germinate, giving rise to a fungous thread, which enters the tissues and finally produces the characteristic yellow or orange-colored spots. Later the cluster cups are formed on the underside of the leaf and on the fruit spots. In these cups are produced another kind of spore, which is carried back to the cedar trees, as previously indicated. This takes place during July, August, and September. The spores produced on the apple can not reinfect this plant, but must find their way to the cedar or perish. Spores for the infection of the apple must come from the cedar.

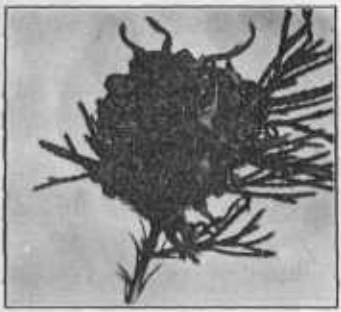

FIG. 10.—Cedar rust disease on the cedar. (Cedar apple.)

### INFECTION PERIOD.

Plenty of moisture is required, both for the production of spores on the cedar apples and for the germination of these spores on the leaves and fruit of the apple. It naturally follows, then, that a serious outbreak of the disease is likely to occur during a wet spring, while if dry weather prevails very few, if any, infections can take place. Beginning about the time apple trees are in bloom, infections may take place over a period of three to six weeks, depending upon weather conditions. In warm, wet weather during this period the cedar apples throw out the yellow gelatinous masses in which the spores are produced. These may dry out and swell up again several times with alternate dry and wet weather, more spores being liberated each time. Such weather conditions prolong the infection period and result in a serious outbreak of the disease on the apple.

### TREATMENT.

Since the fungus causing the disease comes from the cedar trees and since the apple can not become infected from any other source, the natural and most effective remedy is to destroy all red cedars in orchard districts. The cedars in fields or woods adjacent to the

orchards are the most dangerous, but since the spores are like particles of dust they may be carried on the wind for several miles. However, upon being carried so far they would be scattered over a wide area and the chances for serious infection of any one orchard would usually be slight, especially since moisture is necessary for the germination of the spores after they reach the apple. Orchards with no cedar trees within a mile may be considered fairly safe from infections. In cleaning up the cedars, the underbrush, fence rows, and hedges should be carefully searched for young cedars. Little cedar plants only a foot high often have cedar apples, and these are usually overlooked by the orchardist.

Spraying has not proved entirely satisfactory in the control of this disease, although much can be accomplished by this method. The usual treatment for scab and leaf-spot, namely, spraying (1) just before the blossoms open, (2) as soon as the petals fall, and (3) three weeks later, will largely prevent this disease during some seasons. In showery weather, however, an extra application should be made about 10 days after the petals fall. The sulphur sprays appear to be somewhat more satisfactory for this disease than the copper sprays.

FIG. 20.—Apple leaf-spot on leaf of Ben Davis apple.

## APPLE LEAF-SPOT.

With the possible exception of cedar rust, leaf-spot, also known as frog-eye, is the most important fungous disease affecting the foliage of apple. It occurs in all sections east of the Rocky Mountains where the apple is grown and in unsprayed orchards causes considerable damage by defoliating the trees.

The spots are circular or somewhat irregular in outline, and reddish-brown in color, becoming grayish with age. (See fig. 20.) At first they appear as minute purple specks, which rapidly enlarge until a diameter of from one-eighth to one-half inch is reached. The mature spots are usually circular, but after midsummer may become irregular or lobed in outline, due apparently to a secondary extension

of the disease from two or more points on the margin of the original spot.

The leaf-spot disease begins to appear early in the spring soon after the first leaves unfold and infections may continue to take place until midsummer or somewhat later. A large number of spots may occur on a single leaf and in bad cases the trees may become defoliated six weeks or two months before the ripening time of the fruit. As a result of this premature defoliation the fruit either drops off or remains small and is of poor quality, the fruit buds are so weakened as to decrease the chances for a crop the following year, and the trees are materially weakened.

### CAUSE OF THE DISEASE.

The black-rot fungus known as *Sphæropsis malorum* Peck is the cause of apple leaf-spot, or at least it is the most common cause. Other fungi frequently occur on the diseased areas, but they are apparently secondary, and it has never been definitely proved that any of them are capable of producing the leaf-spot described above.

The black-rot fungus is perhaps the most common fungus that occurs in pome fruit orchards. In addition to the apple leaf-spot, it is the cause of the black-rot of apple, pear, and quince, and produces cankers on the trunks and branches of these fruit trees. It also grows and fruits on twigs killed by pear-blight and other parasites. Spores are produced in great abundance on these dead twigs and it is from this source that the leaves most commonly become affected. The fungus fruits on the leaves hanging on the trees only sparingly, but after the diseased leaves drop to the ground spores are produced abundantly.

### TREATMENT.

Apple leaf-spot is easily controlled by spraying with lime-sulphur solution. The treatment for apple scab, as already outlined, will effectually prevent this disease, no special treatment being necessary where the usual orchard spraying is practiced. During the process of pruning affected twigs should be cut off and burned, so as to eliminate this important source of infection.

## SOOTY FUNGUS AND FLYSPECK.

Toward the end of the growing season apples may become affected with large sooty blotches composed of dark olive-brown matted fungus threads. When numerous these blotches give the skin of the apple a clouded effect and many fruit growers have learned to call the disease "cloud." The fungus is superficial, growing on the surface of the apple, and it does not produce any noticeable diseased condition of the tissues. However, the sooty or clouded appearance

which characterizes the disease injures the market value of the fruit, rendering it practically unsalable. (See fig. 21.)

With the sooty spots are usually associate groups of small, circular, dark-colored flecks. This is a fungous trouble known under the common name of flyspeck. (See fig. 21.) It also mars the appearance of the fruit, but not to such an extent as the sooty spots. According to Duggar[1] sooty blotch and flyspeck are stages of the same fungus (*Leptothyrium pomi* [Mont. & Fr.] Sacc.), although for years they have been considered as two distinct fungi.

The sooty fungus and flyspeck are common throughout the Eastern States and in unsprayed orchards often cause considerable damage. The fungus thrives best in moist, shaded places and is especially troublesome when cloudy, showery weather prevails during late summer or fall.

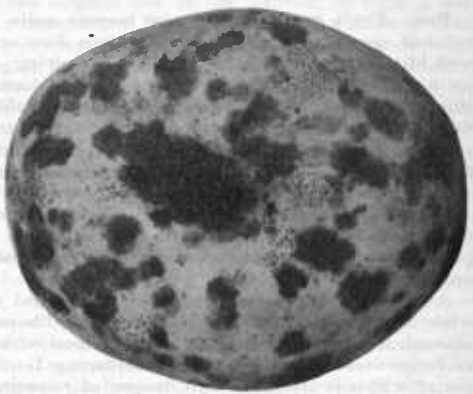

FIG. 21.—Sooty fungus and flyspeck on the Huntsman apple.

### TREATMENT.

The sooty fungus and flyspeck are more easily prevented than any other disease affecting the apple, as would naturally be expected from their superficial habit of growth. When treatment for bitter-rot is practiced these troubles need no further consideration. Even the fungicide in the last spraying for apple scab will hold over long enough largely to prevent them unless the conditions during late summer are specially favorable, in which case an application of Bordeaux mixture or lime-sulphur solution should be made in July. In low, damp situations an application during the first week in July and another during the first week in August, using a weak Bordeaux mixture, will often be found desirable.

## PREPARATION AND USE OF SPRAYS.

The several troubles herein considered are, for the most part, satisfactorily controlled by a thorough use of sprays. During the past

[1] Fungous Diseases of Plants, pp. 367–369.

few years there have been important improvements in the field of orchard spraying as regards the materials used and also in the character of machinery employed. At the present time orchardists, by careful attention to details, are able to obtain a much higher benefit from spraying operations than formerly, and while results vary, depending upon weather and other conditions, yet the successful orchardist now expects to harvest, as sound fruit, from 90 to 95 per cent of his crop. Below are given the spray materials recommended in the present bulletin, with directions for their preparation.

### LIME-SULPHUR SOLUTION.

**Uses.**—Fruit growers have now become quite familiar with lime-sulphur sprays as a remedy for the San Jose scale, peach leaf-curl, and blister mite, and other troubles requiring dormant tree treatment. The lime-sulphur wash, as used on dormant trees, has gone through a good deal of evolution since the California formula was first employed in the East. Whereas a few years ago it was the practice to make the wash at home for immediate use, utilizing for this purpose in many cases very large cooking outfits, the tendency at the present time is toward the employment of the commercial lime-sulphur solution, a concentrate which is kept indefinitely and used as needed, or a similar homemade solution, both of which are prepared on a distinctly different formula from the wash as formerly used.

A distinct advance was made in the control of fungous diseases when it was found that these commercial and homemade lime-sulphur concentrates, properly diluted, could be used with satisfactory results as fungicides on trees in foliage, replacing Bordeaux mixtures, the use of which is attended with danger of russeting the fruit and injuring the foliage, depending upon weather conditions.

**Home-boiled lime-sulphur solution.**—Concentrated lime-sulphur solution, to be diluted and used for the summer spraying of orchards, may be prepared by boiling together for about 50 minutes, 100 pounds of sulphur, 50 pounds of lime, and water to make 50 gallons of concentrated solution. Any finely powdered sulphur of 98 to 99 per cent purity may be used. The commercial ground sulphur is the cheapest form and is as good as the flowers or flour for that purpose. The best grade of fresh stone lime is required for the best results, although a good grade of hydrated lime may be used, provided proper allowance be made for the high percentage of moisture it contains.

The boiling may be done in barrels or vats with steam or in kettles over a fire. An ordinary 75 to 100 gallon food cooker composed of

a kettle with jacket and fire box is perhaps the most convenient and economical outfit for small and medium sized orchards.

Place about one-fourth of the required amount of water in the kettle, bring it to the boiling point, then put in the lime and immediately add the sulphur. Stir vigorously until the lime is slaked, then add sufficient water to finish with 50 gallons of the concentrated solution and boil for 50 minutes. The total time of actual boiling should not exceed 1 hour, and, as a rule, a boiling period of only 50 minutes gives better results. After the sulphur has gone into the solution, combining with the lime to form sulphids, further boiling brings about a chemical change which finally results in throwing some of the sulphur out of the solution to form a sediment. The sulphur should first be passed through a sieve to break up any lumps that it may contain, and there is perhaps some advantage in working it into a thick paste with water before adding it, or the sulphur may be placed in the kettle first and worked into a paste before adding the lime. In order to finish with 50 gallons of solution the kettle should be filled to about 58 gallons, on account of evaporation. If the water evaporates to below 50 gallons more water should be added to make up the loss. A measuring stick with a 50-gallon mark, and other marks as desired, will be found useful in determining the amount of liquid in the kettle. When steam is used the process is about the same as above described. Owing to the condensation of the steam a somewhat smaller amount of water is required. When the boiling is finished the solution should be poured through a strainer of about 20 meshes to the inch, so as to remove the coarse particles of sediment. It may be used immediately or stored in barrels or other containers and kept indefinitely, provided the air is excluded. In practice the fruit growers, as a rule, have not been able to prepare the lime-sulphur solution without obtaining a large amount of sediment and this has tended to make the commercial product more popular. This sediment is due largely to impurities in the lime and improper mixture and boiling. Straining will take out the coarser particles, and the remainder will not prove to be seriously objectionable.

After the sediment has been settled, the clear liquid should test 25° to 28° on the Baumé hydrometer. It takes about 2 gallons of the homemade preparation to equal in strength 1½ gallons of the commercial product, and these amounts, respectively, are the amounts required for each 50 gallons of spray. For the summer spraying of apple trees, lime-sulphur solution, whether home-made or commercial, should be so diluted as to contain 3½ to 4 pounds of sulphur in each 50 gallons of spray. Prepared according to the above directions, 1 gallon of the homemade product contains approximately 2 pounds of sulphur in solution, and therefore 2 gallons would give the

requisite amount of sulphur for each 50 gallons of spray. For spraying trees during the dormant season it should be used much stronger, 12 to 15 pounds of sulphur to each 50 gallons of diluted spray being required. For dormant tree spraying about 7 gallons of the home-made solution in each 50 gallons of spray would therefore give the proper strength.

**Commercial lime-sulphur solution.**—For some years manufacturers of insecticides and fungicides have had on the market concentrated solutions of lime-sulphur, originally designed as treatment for the San Jose scale, which obviated the necessity of orchardists preparing the wash at home. These solutions have now come to have a much wider range of usefulness, forming a satisfactory substitute, in most cases, for Bordeaux mixture as a fungicide. These concentrated solutions, for the most part, are well made and are fairly uniform in strength, registering from 30° to 34° on the Baumé scale. Many orchardists prefer to use them rather than to prepare the spray at home. In the case of small orchards their use is doubtless advisable, but where the orchard interest is considerable the fruit grower might well afford to prepare the concentrate at home.

In the use of the commercial lime-sulphur solution, as in the home-made solution, the orchardist should know rather exactly the proper dilution to make which will insure the control of the troubles in view, and on the other hand not prove injurious to the foliage and fruit. Dilutions are based on the strength of the concentrate as shown by its specific gravity. Thus commercial lime-sulphur showing a density of 32° on the Baumé scale should not be used stronger than 1½ gallons for each 50 gallons of spray. According to the writers' observations a variation of 2° above or below the density indicated is immaterial as regards danger of foliage injury, so that the recommendations hold for practically all of the commercial concentrates on the market. Where the fungous troubles to be treated are not very serious, it is recommended that only 1¼ gallons of the concentrate should be used to each 50 gallons of spray in order to eliminate, in so far as possible, the danger of injury to fruit and foliage.

## BORDEAUX MIXTURE.

Bordeaux mixture is composed of copper sulphate (bluestone) and quicklime, with a certain quantity of water. The amounts of copper sulphate and of lime to be used with a given quantity of water vary somewhat, according to the kind of plants or trees to be sprayed and the disease to be treated. When used on the apple the following formula is quite satisfactory for general orchard work:

| | | |
|---|---|---|
| Copper sulphate (bluestone) | pounds | 3 |
| Quicklime | do | 4 |
| Water to make | gallons | 50 |

In bad cases of bitter rot or apple blotch it is often advisable to use 4 pounds of bluestone nnd 6 pounds of lime to 50 gallons of water instead of the above formula.

**Directions for making.**—To make a single barrel of Bordeaux mixture, dissolve the bluestone in 25 gallons of wnter and in a separate vessel slake the lime and dilute it to 25 gallons. Then pour the two solutions simultaneously through a strainer into the spray tank.

If large quantities are to be used, stock solutions of the bluestone and lime should always be prepared, thus saving the time necessary to dissolve the materials. A stock solution of the copper sulphate may be made by dissolving it at the rate of 1 pound to each gallon of water. Fill a 50-gallon barrel two-thirds or three-fourths full of water, and place a sack (or box with perforntions in the bottom and sides) containing 50 pounds of copper sulphate in the upper part of the barrel, suspending it by a string or copper wire. In from 12 to 24 hours the sulphate will have entirely dissolved, aud the sack or box should be removed nnd enough water added to fill the barrel. After slight stirring the solution is ready for use. The stock lime may be prepared by slaking 50 pounds in a barrel or other vessel, and finally adding water to make 50 gallons. In slaking the lime sufficient water should be used to prevent burning, but not enough to "drown" it, and the mass should be continually stirred with a shovel or spading fork until a thin paste is formed.

In making Bordeaux mixture take the necessary quantities of the stock copper sulphate and the stock lime solutions to give the formula in the total amount of water to be used, and place each in separate elevated dilution tanks, which should hold half as much as the total capacity of the spray tank. Thus, if the spray tank holds 200 gallons each dilution tank should hold 100 gallons, and, according to the above formula, 20 pounds of copper sulphate (20 gallons of the stock solution) and 20 pounds of lime (20 gallons of stock solution) would be required. To each dilution tank add water (one-hnlf the total amount of spray) and after stirring allow the diluted ingredients to run through separate hose or troughs attached to faucets near the bottom of the tank into the strainer on the spray tank, where the two solutions come together, producing the Bordeaux mixture. Only the quantity which can be used during the day should be mixed, as the Bordeaux mixture deteriorates on standing.

In case the dilution tanks are not elevated to admit of filling the spray tank by gravity, the diluted solutions must be dipped and poured into the latter by hand, a bucketful of each simultaneously. This method is advisable in small operations, where a few barrels at most are needed.

It is important that Bordeaux mixture should be thoroughly strained in order to keep out any coarse particles that would clog

the spray nozzles, and it is a good practice to strain the stock solution of lime while pouring it into the dilution tank. The best material for a strainer is brass wire netting of about 20 meshes to the inch.

### ARSENATE OF LEAD AND OTHER ARSENICALS.

Arsenate of lead is the principal arsenical used in orchard spraying. It comes on the market in a puttylike paste and to a more limited extent in the form of a powder. Its present large use is due to certain advantages it has over other arsenicals, in that it contains very little water-soluble arsenic, and is therefore much less likely to injure the foliage. It also adheres better than other arsenicals, such as Paris green and arsenite of lime. All arsenicals used in spraying fruit trees may be used in Bordeaux mixture. However, not all of these can be used in lime-sulphur solutions without danger of foliage injury. Arsenate of lead when added to lime-sulphur solution undergoes considerable chemical alterations, as shown by the prompt change in color of the mixture. Chemical analyses show that a small percentage of the arsenate of lead is broken down, and lead sulphid and arsenate of lime formed. Abundant experience, however, has shown that this alteration of the chemical nature of the arsenical and of the lime-sulphur wash does not injuriously affect their efficiency as fungicides and insecticides, nor materially add to the danger of foliage or fruit injury. Arsenate of lead is used in Bordeaux mixture or lime-sulphur at the rate of 2 pounds to each 50 gallons of the spray. As there are numerous brands of arsenate of lead upon the market the grower should be careful to purchase from reliable firms. When the paste form of arsenate of lead is used it must be worked free in water before it is added to the spray. Powdered arsenate of lead is used at about one-half the strength of the paste form.

In large spraying operations it will be more convenient to prepare in advance a stock mixture of arsenate of lead as follows: Place 100 pounds of arsenate of lead in a barrel, with sufficient water to work into a thin paste, diluting finally with water to exactly 25 gallons. When thoroughly stirred each gallon of the stock solution will thus contain 4 pounds of arsenate of lead, the amount necessary for 100 gallons of spray. In smaller spraying operations the proper quantity of arsenate of lead may be weighed out as needed and thinned with water. In all cases the arsenate of lead should be strained before or as it is poured into the spray tank. The necessary care should be exercised to keep the poison out of the reach of domestic and other animals.

Arsenite of lime is recommended by Stewart[1] as an arsenical for use in lime-sulphur solution, but when so employed the Kedzie formula should be somewhat modified as follows:

| | | |
|---|---|---|
| White arsenic | pounds | 2 |
| Sal soda crystals[2] | do | 2 |
| Water | gallons | 1½ |

Boil the above ingredients together in an iron vessel until entirely dissolved, which will require about 15 minutes. This solution is then used to slake 3 or 4 pounds of best stone lime. If the slaking is thoroughly done, the arsenic will be well combined with the lime and the product will retain its strength indefinitely. After slaking, add enough water to bring the total up to 2 gallons. This is a stock solution, which after having been labeled to indicate its poisonous nature, may be stored for use as needed. The stock solution, after thorough stirring, is used at the rate of 2 pints for each 50 gallons of lime-sulphur spray and contains the equivalent in arsenic of one-half pound of Paris green.

This preparation may be used equally well in Bordeaux mixture. Paris green may be used in Bordeaux mixture at the rate of 5 or 6 ounces for each 50 gallons of spray. This poison, however, should not be used in lime-sulphur spray.

## SCHEDULE OF SPRAY APPLICATIONS.

In connection with the several insects and diseases previously referred to, information has been given as to the treatment to be employed in their control. It rarely happens, however, that the orchardist has to consider only one or two of these troubles, there being present as a rule several important insect or fungus pests which must be considered. Fortunately for the orchardist, many of his most serious troubles permit of control by a few well-timed applications of a combined insecticide and fungicide, such as lime-sulphur wash and arsenate of lead. It is, therefore, possible to indicate a schedule of applications which has been found satisfactory to protect fruit and foliage from injury. An outline of this kind, however, must be very elastic to apply to the varied conditions obtaining in the various orchard sections of different parts of the country, as, for instance, in the New England States and in the Ozark region of Arkansas. The orchardist, therefore, must know what his troubles are in order to save himself the expense of unnecessary treatments, on the one hand, and of serious loss, on the other, on account of failure to spray where such work is desirable. The following schedule of applications is recommended, and if carefully followed out it

[1] Bul. 99, Pennsylvania Agricultural Experiment Station.
[2] If the anhydrous or water-free sal soda is used, one-half the quantity will be sufficient.

should insure protection against practically all of the troubles affecting the fruit and foliage of the apple:

**First application.**—Use lime-sulphur solution at the rate of 1½ gallons to 50 gallons of water plus 2 pounds of arsenate of lead paste or 1 pound of powdered arsenate of lead just before the blossoms open. This is for apple scab, the plum curculio, cankerworms, the bud moth, case-bearers, and the tent caterpillar.

**Second application.**—Use same spray as in first application, as soon as the blossoms have fallen. This is for the above-mentioned troubles as well as for the codling moth, leaf-spot, and cedar rust. It is the most important application for both apple scab and the codling moth. In spraying for the codling moth at this time the aim is to place in the calyx end of each little apple a quantity of the poison and, to accomplish this, painstaking work will be necessary. Failure to do thorough spraying at this time can not be remedied by subsequent treatments.

**Third application.**—Use the same spray as indicated above three to four weeks after the blossoms fall. This is the second treatment for the codling moth, cedar rust, and leaf-spot, and gives further protection against apple scab.

**Fourth application.**—Use Bordeaux mixture (3–4–50 formula) and an arsenical eight to nine weeks after the petals fall (about June 25 to 30). This is the first application for bitter rot, the arsenical being added for the second brood of the codling moth. It is also essential for the sooty blotch and flyspeck, especially in damp situations.

The applications given above, if carefully followed out, are, as a rule, sufficient to bring the fruit crop through to maturity in good condition, except where bitter rot occurs, for which further treatment will be necessary as indicated below.

**Fifth application.**—Use Bordeaux mixture from two to three weeks after the fourth application. This is the second application for bitter rot, and since it is very little extra expense to add an arsenical this may be profitably done as a further protection against late-appearing larvæ of the codling moth.

**Sixth application.**—Use Bordeaux mixture again two or three weeks after the fifth treatment has been applied. This is the third application for bitter rot and is ordinarily sufficient to carry the fruit through, but on specially susceptible varieties in bitter rot sections, a treatment to be made two weeks later may be found necessary.

**Apple-blotch treatment.**—The second, third, and fourth applications of the above schedule will control mild cases of apple blotch, but in bad cases an extra treatment, using Bordeaux mixture, applied six weeks after the petals have fallen (two or three weeks after the second application), will be found necessary for the best results.

Many orchards located in the Middle Atlantic States and southward do not require the first application of the above schedule. Only bud-scabbing varieties, like Winesap, need spraying at this time, unless cankerworms or the bud moth should prove serious enough to necessitate a special spraying. The York Imperial and Ben Davis varieties, which constitute a large proportion of the orchards throughout this region, rarely need spraying before the trees bloom.

## EQUIPMENT FOR SPRAYING.

With other conditions favorable, the orchardist will not be able to secure satisfactory results in spraying unless he uses an efficient spraying outfit. While there has been a notable improvement in the character of spraying machinery used by orchardists during the last few years, there are yet many outfits in use which greatly handicap the work. At the present time there are on the market a large series of makes of spray pumps, many of which are quite efficient for the purpose for which they are designed, and the orchardist should not be satisfied with any but the best.

The barrel type of spray pump is serviceable in small to medium sized orchards and when properly fitted with hose of sufficient length, a good agitator, and good nozzle, very effective work may be done. The pump, according to design, may be fitted to the end or side of the ordinary 50-gallon kerosene or similar barrel and may be mounted on a sled or wheels, or preferably placed in a cart or wagon. One man is required to pump and one or two men to handle the nozzles, depending on whether one or two leads of hose are used. A good barrel pump should supply two leads of hose, each with double nozzles. Tank outfits are mostly used in the larger orchards, but are very desirable for the small orchardist as well. These outfits consist of rectangular or half-round tanks, flat on top, holding from 100 to 300 gallons of the spray mixture, fitted to the wagon in place of the wagon bed. Some growers use a 100 to 200 gallon tank placed on one end of the wagon. The barrel type of pump may be used on these tanks, but for this purpose it is better to use the larger tank pumps with suction hose. The hole in the top of the tank should be covered with a close-fitting lid to keep out leaves, twigs, and other trash, which would clog the pump and nozzles.

However, in large commercial orchards power sprayers are mostly used, such as gasoline, compressed air, etc. With such outfits a much higher pressure may be maintained than is possible with hand pumps, giving a fine spray, which may be driven to all parts of the tree. Sufficient power will be furnished to supply several leads of hose and the spraying may be done rapidly, which is very important, especially in regions where suitable days for spraying are not fre-

quent. The usual defect in spraying outfits is that the hose is not of sufficient length. Each lead of hose should be from 25 to 35 feet long, and provided with an 8-foot to 12-foot bamboo extension rod. This length of hose will permit the complete spraying of a tree before leaving it, insuring more thorough work than if only one side is sprayed at a time, and the amount of driving necessary will be reduced by one-half.

The nozzle, of which there are many kinds on the market, is a very essential part of the spraying outfit. Whereas a few years ago the nozzles available were far from satisfactory for orchard spraying, there are now to be obtained good nozzles for the purpose. For general spraying the Vermorel or eddy chamber type of nozzle, of which there are various modifications, is best. These nozzles give a spray of different degrees of fineness, depending upon the size of the aperture of the cap used. In the spray application given immediately after the falling of the petals, especially to lodge poison in the calyx cups for the control of the codling moth, a cap with a large opening is used by many orchardists, and some fruit growers, especially in portions of the West, use at this time a still coarser spray, as that from the "Bordeaux" or similar nozzles. Information on this point as obtained by the Department of Agriculture under humid conditions indicates that there is no advantage in using so coarse a spray, such as is produced by Bordeaux nozzles, especially since a much larger amount of spray is required and greater injury may result.

In spraying high trees some form of elevated platform should be constructed on the wagon, on which one of the men holding the nozzles may stand to spray the higher parts of the tree, the other men spraying from the ground as high as may be reached and overlapping the work of the men on the tower.

In many commercial orchards more time is consumed in driving to and from the water supply than in actually applying the spray. This can be remedied by the use of a supply tank which will hold 200 to 300 gallons. One hand should be able to prepare the mixtures and deliver them to the sprayers in the orchard, thus keeping the outfit constantly in operation. The mixture may be quickly transferred from the supply tank by means of a rotary pump attached to the engines or by other tank-filling devices.

## APPLYING THE SPRAY.

Sprays are preventive and not curative, and must therefore be applied before the injury becomes apparent. After a fungus has gained entrance to the foliage or fruit it can not be reached and the diseased parts made sound again; but the infection may be prevented

by coating the parts with a fungicide, such as lime-sulphur solution, which prevents the germination of the spores. Similarly, the codling moth may not be poisoned after it has burrowed into the fruit, but if the poison has been put into the calyx cavities before the calyx lobes have closed, and has been sprayed on the foliage and fruit before the latter is entered by the larvæ, the destruction of the latter in large numbers is insured. Successful spraying, therefore, must be based on a knowledge of the diseases and insects to be controlled. With all of the affections here considered the work should be done in advance of their expected appearance in the orchard.

There are two principal reasons why spraying in the hands of some is unsatisfactory, namely, failure to make the applications at the proper time and failure thoroughly to coat the trees and fruit with the mixture. In order to overcome the former difficulty the orchardist must be informed as to the nature of the malady or insect to be treated, and the latter may be overcome by maintaining proper equipment and by giving the necessary attention to thoroughness in spraying.

In the operation of spraying the liquid should be broken into a very fine mist. The nozzles should be so manipulated that every part of the foliage and fruit shall be uniformly covered with fine dots of the spray. It is not necessary that the foliage and fruit should be actually coated with the spray, but every portion should be thickly peppered with it. The higher and inner portions of the tree are commonly insufficiently sprayed, and while the liquid may actually be dripping from the lower branches the upper parts of the tree may show little of the spray.

The desired mistlike spray can ordinarily be secured only with high pressure at the pump. This pressure should be not less than 100 pounds, though this is not ordinarily obtained except with gasoline or other power outfits, which should supply a pressure of 125 to 150 pounds. When hand pumps are used the pressure should be maintained as high as practicable, and never less than 75 pounds, in which case good nozzles become more essential for perfect work. To maintain this pressure will require constant hard work, and the tendency will be to allow the pressure to lighten. Except in spraying the tops of trees the nozzle men should never ride in the wagon, even while spraying the smallest trees. In order to reach the inner branches and the underside of the fruit and foliage the operator must spray from the ground, where he is free to walk around and under the trees. Many failures result from attempts to spray trees from the wagon as the outfit is being driven by.

The question is frequently asked, especially by persons not much experienced in spraying, as to the proper quantity of spray required

per tree. This information is not only an index to the thoroughness of the spraying that is being done, but is especially useful in arriving at an estimate of the amount of spray chemicals to be purchased.

The quantity of liquid to be used on trees and foliage naturally varies with the size of the tree. For orchards just coming into bearing and with average-sized trees 8 to 10 years old, a proper manipulation of the nozzle should insure thorough spraying with 3 or 4 gallons per tree. For average-sized trees 12 to 15 years old the amount of spray required per tree would be from 5 to 7 gallons, and for older trees a larger quantity will be required, all varying with the size of the opening in the nozzle used and the rapidity with which the work is done. Very old trees of considerable height and spread of limbs often require from 10 to 15 gallons per tree to insure a thorough treatment.

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